Renal Scintigraphy in Renovascular Hypertension Secondary to Stenosis of a Supplemental Renal Artery

Guest Editor: Theodore Simon
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CASE DESCRIPTION

A 46-yr-old white male had abdominal pain and acute onset of pancreatitis and arterial hypertension (200/120 mmHg). His erythrocyte sedimentation rate (ESR) was elevated (47), but his serum creatinine and blood urea nitrogen were normal. He was felt to have systemic vasculitis. He was, therefore, treated with steroids (prednisone 30 mg b.i.d.), beta-blockers (atenolol 50 mg b.i.d.), and calcium-channel blockers (diltiazem 20 mg b.i.d.).

The patient was admitted to the National Institutes of Health (NIH) 7 wk later. On therapy, blood pressure was well controlled (120–130/80–90 mmHg). His ESR was 10, serum creatinine was 1.1 mg/dl, and blood urea nitrogen was 22 mg/dl.

IMAGING FINDINGS

Explanation of Scintigraphic Method

The patient underwent technetium-99m- (^{99m}Tc) diethylenetriaminepentaacetic acid (DTPA) and iodine-131- (^{131}I) orthoiodohippurate (OIH) renal scintigraphy. Studies were performed in the posterior projection with the patient supine. A large field-of-view gamma camera (Siemens Orbiter, Hoffman Estates, IL) was used with either a general all-purpose collimator for the DTPA, or a medium-energy collimator for the OIH study. A dose of 15 mCi (555 MBq) DTPA was injected intravenously as a bolus. A flow study with 2-sec temporal resolution was obtained for 1 min followed by sequential imaging every 2 min for 24 min. The collimator was then changed and the OIH study was performed using 300 μCi (11.1 MBq) of OIH given intravenously. Images were recorded every 2 min for 24 min with a simultaneous quantitative acquisition framed at 30-sec intervals. For both studies, the images on radiographic film were complemented by computer-generated time-activity curves. We calculated individual kidney function from the net kidney activity recorded at 2 min after injection.

In order to interpret the OIH study, we evaluated: the intensity of the renal cortical activity at 18 to 24 min compared to images taken at 2–4 min (visual analysis); up-slope, peak time, and down-slope of the renal time-activity curve; and the split renal function expressed for each kidney as a percent of the net total counts of both kidneys observed at 1–2 min after injection. In normal subjects, the peak cortical activity occurs at 2 to 5 min after injection. Visual analysis indicates that normally much less cortical activity is seen at 18 to 24 min than at 2–4 min after injection. Quantitatively, <30% of the peak activity remains as cortical residual activity at 24 min.

The following analyses were used for the DTPA study: the overall intensity of the renal cortical and collecting system activity during the entire 24-min period; the shape of the time-activity curves during the up-slope, peak time, and down-slope; and split renal function. In normal subjects the kidneys are well-visualized with the parenchymal activity peaking at 3 to 5 min. The renal DTPA activity is symmetric for equally sized kidneys in patients with normal renal function.

Explanation of Imaging Findings

The DTPA study showed a reduction of blood activity to the right kidney when compared to the left. This reduction was evident on the flow images (2-sec intervals) (Fig. 1). Sequential 2-min images showed poor visualization of the right renal cortex, consistent with depressed right glomerular filtration (Fig. 2). OIH ren-

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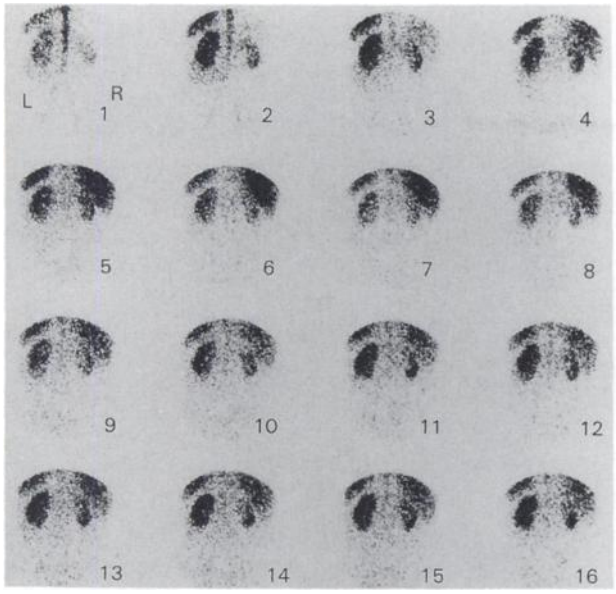

FIGURE 1
DTPA dynamic flow study (2-sec intervals) shows decreased right renal perfusion.

ogram curves showed decreased perfusion and slow washout in the right kidney (Fig. 3A) compatible with renovascular disease. However, the right kidney showed nonuniform perfusion: the lower pole initially contained much more activity than the upper pole (Fig. 2). Activity in both poles of the right kidney evened out over time. Upper pole activity then exceeded that in the lower pole (Fig. 3B). Therefore, although the overall function of the right kidney was markedly abnormal, the abnormality appeared as confined to the upper right renal pole. The lower pole appeared to fill and empty normally. The overall right renal volume was, however, less than the left renal volume.

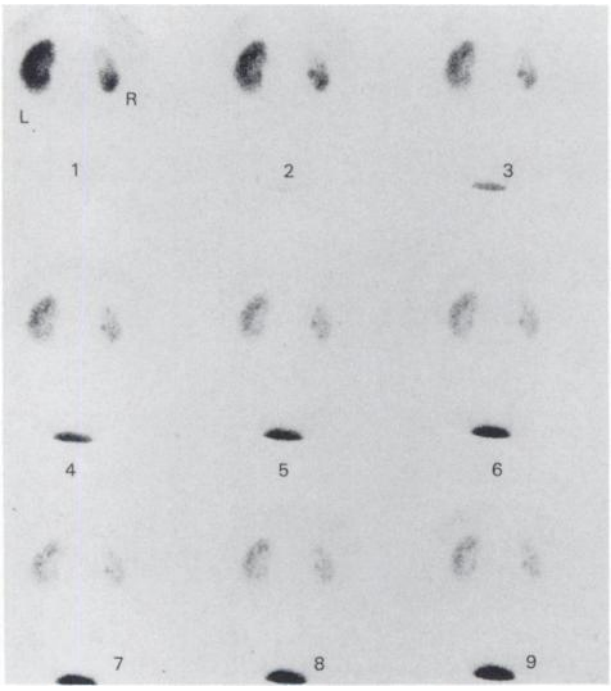

FIGURE 2
DTPA sequential images (2-min intervals) show poor visualization of the right renal cortex, consistent with decreased right glomerular filtration.

An aortogram was performed at another hospital using intraarterial digital subtraction angiography, and reviewed at the NIH. It demonstrated a normal left renal artery, normal abdominal aorta, and abnormal right renal vasculature. There were two separate right renal arteries originating almost next to each other (Fig. 4A). In addition, the branch which supplied the upper pole of the right kidney was selectively injected and demonstrated rapid tapering distal to the origin of the capsular and adrenal branches to a fusiform type lesion (Fig. 4B). Distal to the fusiform lesion, the vessel first narrowed and then demonstrated some poststenotic dilatation. The intrarenal branches appeared unremarkable. The nephrogram of this area was typical of a kidney with renal artery stenosis: it demonstrated a small kidney with a smooth cortex. Other arteries (carotid, subclavian, superior mesenteric, celiac, hepatic, splenic) were normal.

DISCUSSION

In patients with suspected renovascular hypertension, accurate assessment of the vascular disorder is important. Advances in surgical and percutaneous angioplasty techniques (*1,2*) have renewed interest in detecting correctable renal artery stenosis in these patients. Physicians require invasive techniques, such as arteriography, to establish the definitive diagnosis. However, renal artery stenosis and both global and split quantitative renal function can also be evaluated noninvasively using radionuclide renography (*3–5*).

The diagnosis of potentially curable renovascular hypertension should be performed in a sensitive, safe, and cost-effective fashion (*6*). Demonstration of causality between the renal arterial lesion and the hypertension is essential to the diagnosis of renovascular hypertension. Normotensive patients may often have substantial renal artery stenosis (*7,8*) and hypertensive patients with renal artery stenosis have been found not to improve following technically successful repair of the renal arterial obstruction (*9*). Whereas angiography is the gold standard for the diagnosis of renal artery stenosis, demonstration of an anatomic abnormality does not indicate renovascular hypertension. Similarly, an angiographic image of renal artery stenosis does not predict the response of hypertension renal artery angioplasty (*7–10*). Previous papers have suggested that radionuclide renography represents an effective way to detect renal artery stenosis and to study both global and split renal function (*3–5*). This technique has several distinct advantages as a diagnostic test: it is safe; easy

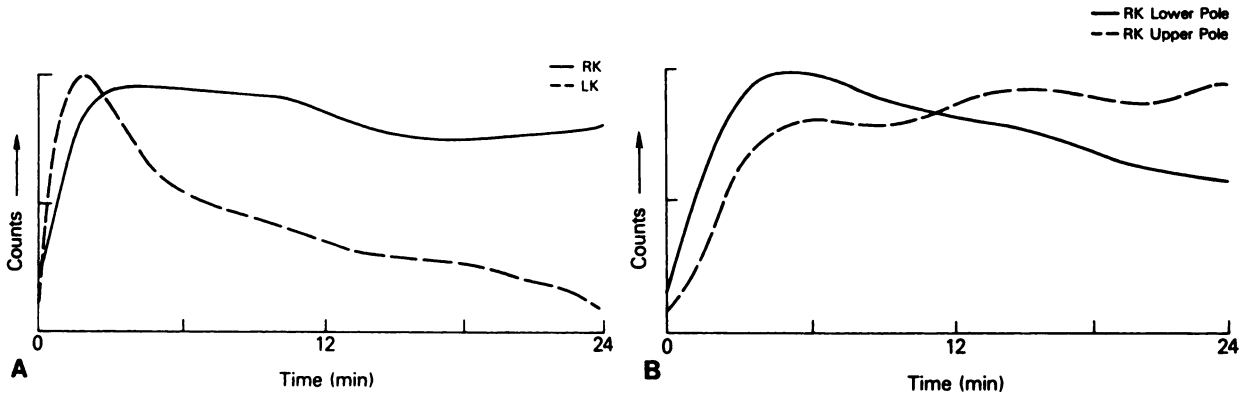

FIGURE 3
(A) OIH renogram curves show decreased perfusion and slow washout in the right kidney, compatible with renovascular disease. (B) OIH renogram curves obtained from the upper pole and the lower pole of the right kidney: the upper pole shows decreased perfusion and slow washout compared to the lower pole.

to perform; and has high sensitivity for differentiating between normal and abnormal renal function. Radionuclide renography can also noninvasively demonstrate asymmetrical or unilateral renal disease (*11*). However, the sensitivity for diagnosing renal artery stenosis with scintigraphy is inconclusively documented, but is believed to be 60%–80% (*12*). Furthermore, the renal scintigraphic findings in renovascular hypertension are not specific, since renal vein thrombosis, acute complete ureteral obstruction, acute tubular necrosis, and

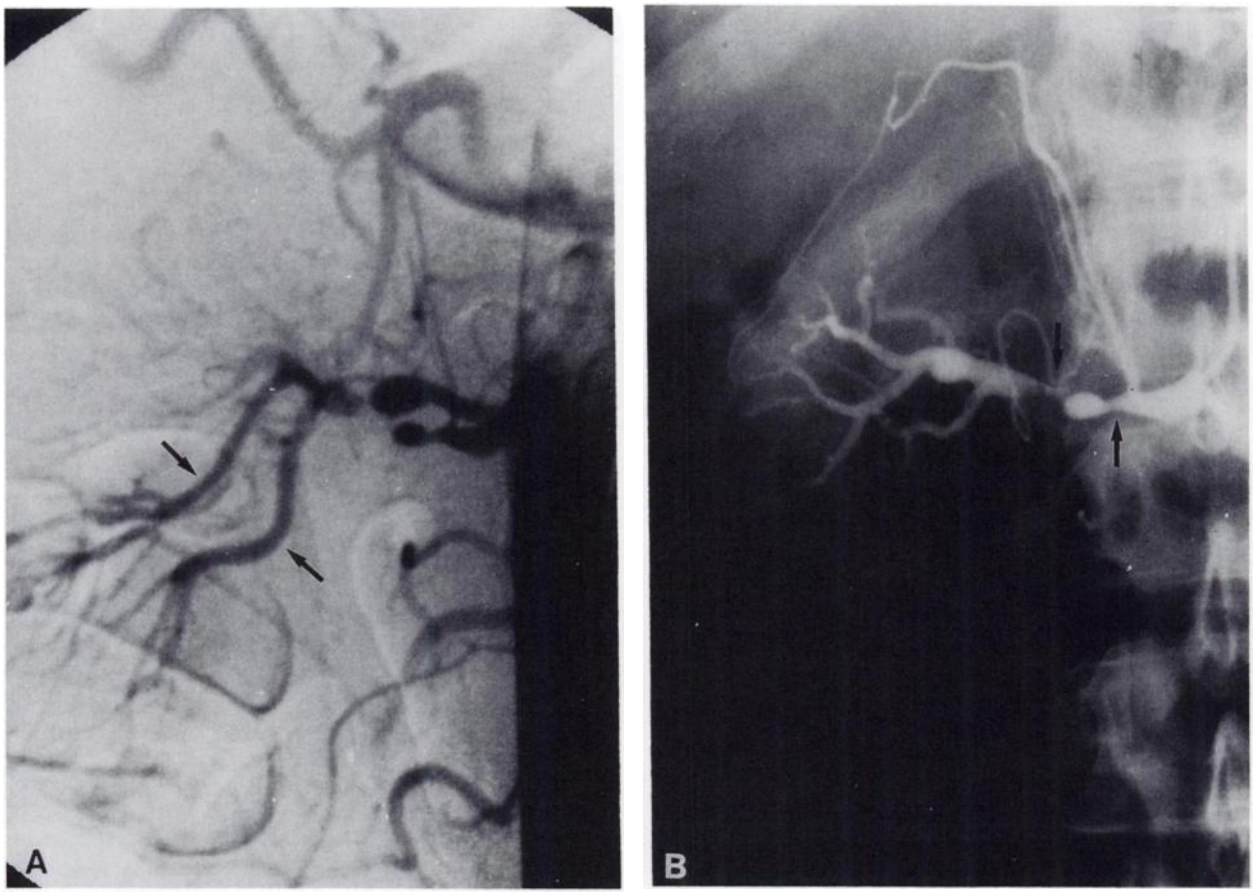

FIGURE 4
(A) Abdominal aortogram demonstrates two right renal arteries. Intrarenal branches to the lower pole of the kidney are well seen (arrows), upper pole branches are not seen. (B) Selective angiogram of the vessel supplying the upper pole of the right kidney. Two segmental stenoses are evident (arrows).

renal failure may mimic the pattern observed in renovascular hypertension (*13*). It appears that the introduction of captopril renography will greatly improve the efficacy of the radionuclide renogram in the differential diagnosis of renovascular hypertension (*10,14, 15*).

We describe the renal scintigraphic findings in a patient with arterial hypertension secondary to stenosis of a supplemental renal artery. The abnormalities were observed in the flow phase and in sequential static images. The perfusion and the function of the right kidney were markedly abnormal compared to the left. As a result, the right kidney showed nonuniform perfusion and function. In particular, the upper pole demonstrated delayed perfusion and depressed function compared to the lower pole, which appeared to fill and empty normally. The results of the radionuclide renography matched the angiographic findings: two separate renal arteries supplying the right kidney. The branch supplying the upper pole demonstrated narrowing and post-stenotic dilatation.

In both the normotensive and hypertensive populations, ~30% of persons have multiple arteries supplying at least one kidney (*16,17*). Graves (*18*) and Bojisen (*16*) demonstrated that the kidney may be divided into five vascular segments. The upper and apical segments are normally supplied by a superior branch from the main renal artery (*16,18*), but in our patient it was supplied by a separate renal artery.

Previous studies have indicated that renovascular hypertension can be satisfactorily treated in most patients with percutaneous transluminal angioplasty or with surgical intervention (*1,2*). Indications for intervention depend on the site and severity of renal artery damage. Dilatation of unilateral renal artery stenosis appears to achieve better results than dilatation of bilateral stenosis (*19*). Moreover, patients with renovascular hypertension present several clinical problems related to both the selection of the best time for intervention and the choice of the most appropriate procedure. Finally, since the disease is progressive, investigators need long-term follow-up and repeated evaluation of renal perfusion and function to optimize therapy. It is also important to emphasize that scintigraphic findings reflect the current condition of the kidneys and can be compared only with contemporaneous angiography. Follow-up renal scintigraphy is easy to perform, is well tolerated, and can provide quantitative data with individual kidney clearances and split renal function analysis. This technique is valuable for periodic evaluation of the hypertensive patient on medical treatment, or the patient having undergone renal artery percutaneous angioplasty or surgical revascularization (*20*). Progression or recurrence of the disease, as well as the functional status of the kidneys, can be evaluated in a safe noninvasive way.

IMPACT ON MANAGEMENT

The imaging findings established the cause of the patient's arterial hypertension. Since blood pressure is currently well controlled on moderate medical management with beta blockers (atenolol 50 mg b.i.d.) and calcium channel blockers (diltiazem 20 mg b.i.d.), there is no urgent need to consider performing invasive procedures for treatment. Resurgence of uncontrolled hypertension will renew consideration of percutaneous renal artery angioplasty or surgical intervention.

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MAY 1975

Tumor Imaging After Administration of Technetium-99m-Labeled Bleomycin

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Physicians have long desired a sensitive, simple test to detect and localize malignant neoplasms. Bleomycin has been known to have an inhibitory effect on cancers of epithelial cell origin. Recently, the clinical utility of cobalt-labeled bleomycin for tumor imaging was reported. However, the long half-life of ^{57}Co limits its wide use.

We have prepared ^{99m}Tc-labeled bleomycin. Metabolism, toxic effect, and tumor affinity were studied in normal and tumor-bearing mice. To determine appropriate scintigraphic timing and to study the stability of labeled compounds, serial measurements of plasma radioactivity were made on four patients with different malignant tumors. A larger series of 142 patients was then examined.

Our studies suggest that ^{99m}Tc-labeled bleomycin localizes relatively quickly into a number of different tumor types, while uptake in nonmalignant inflammatory lesions is infrequent. Its use as a diagnostic agent is associated with a very small whole-body radiation dose.

The method has one disadvantage: high radioactivity distribution in the kidney, urinary bladder, nasal area, and circulating blood pool. This might be responsible for lower detectability rates in patients with cancer of the esophagus and of the abdominal and pelvic organs. ■

Half-Life

Kanji Torizuka, MD, President of Fukui Medical School

Since its introduction by Edwards et al. in 1969, gallium-67-citrate had been the predominant tumor-seeking agent utilized in our laboratory. Because of its relatively low specificity, however, we were actively seeking a more sensitive and specific agent for the detection of malignant neoplasms.

Kyoto University's nuclear medicine department was very different then. There was only one scintillation camera and one whole-body scanner in the entire department. By working with our colleagues in the radiopharmaceutical department, however, we became aware of the rapid progress of research into the chemistry of ^{99m}Tc. It was, in fact, discussions with our colleagues regarding labeling techniques which led us to believe that bleomycin labeled with ^{99m}Tc had great potential as a tumor imaging agent.

That was the beginning of a long and fruitful relationship between ourselves and the radiopharmaceutical investigators, a relationship which has resulted in many exciting new products.

Today many excellent physicians and investigators are actively engaged in the study of nuclear medicine, and they have access to a wide array of instrumentation, including PET.

When I look back upon these past 15 years, a thousand emotions crowd my mind. ■